Statement of Work (DRAFT)
Manufacturing and Integration of the HEEET Engineering Test Unit

Heatshield for Extreme Entry Environment Technology (HEEET) Project

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National Aeronautics and Space Administration
Ames Research Center

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1.0 Introduction

The Heatshield for Extreme Entry Environment and Technology (HEEET) Project, co-funded by NASA's Space Technology Mission Directorate under the Game Changing Development Program (GCDP) and by NASA's Science Mission Directorate (SMD), seeks to mature a Thermal Protection System (TPS) technology that will support in-situ robotic science missions recommended by the NASA Research Council (NRC) and Planetary Science Decadal Survey (PSDS) committee. The HEEET project is led out of NASA Ames Research Center, in partnership with Langley Research Center, Johnson Spaceflight Center, Kennedy Space Flight Center and various groups in industry.

The key component of the HEEET project is the dual-layer, 3D woven carbon fabric which functions both as an efficient ablator and as an insulator, thereby reducing the areal mass when compared to other rigid TPS systems. The woven 3D woven material is infused with a phenolic resin that rigidizes the weave and allows for conventional machining operations. Due to manufacturing limitations in the weaving process, the largest single piece that can be fabricated is 24x24 in^2. Therefore the joining, or integration of tiles with adhesive is required to form a larger heat shield.

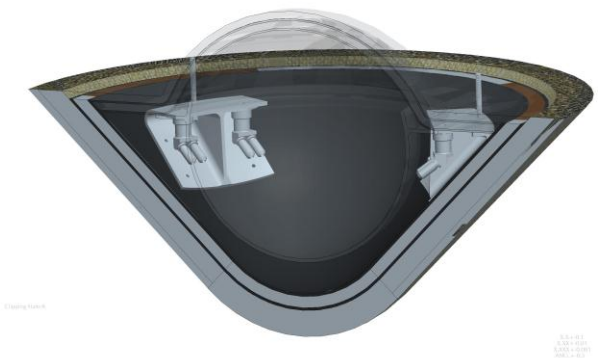
The purpose of this Request for Information (RFI) is to gather and assess current industry capability and availability to support the integration of a 1-meter heat shield. The integration process must maintain tight tolerance control to not compromise the thermal or structural performance of the system. The ability to leverage past experience and existing facilities is desirable, especially if it pertains to the possible extension in scale of future articles to the 3.5 meter class. Note that some information referenced throughout this document will be provided as a separate Export-Controlled Appendix that will be available upon request.

1.1. Engineering Test Unit (ETU)

The 1-meter heat shield to be integrated is referred to as the Engineering Test Unit (ETU) in this document. The ETU is the primary deliverable for the HEEET project that is to be assembled on a flight-like carrier structure and put through a series of environmental tests. There are four primary goals associated with the development, manufacturing, and testing of the ETU:

1. Verification of structural performance of ETU and model correlation
2. Demonstration of manufacturability and integration at relevant scale
3. Demonstration of defect inspection and identification of entire heat shield at full scale
4. Demonstration of NASA's ability to transfer prototype component manufacturing insight to outside partners, levy efficient and effective requirements, and verify that delivered hardware is acceptable

The ETU support structure and TPS panel configuration are presented in Figure 1. The support structure is a composite sandwich skin with aluminum honeycomb core and three Titanium fittings. The TPS that will be integrated onto the support structure consists of several distinct tile shapes. The nosecap tile, which is on the apex of the sphere-cone will terminate at either the tangency point between the spherical to conical section, or extend up to 3 inches onto the conical section. Two circumferential rows of tiles are present on the conical section of the heat shield. Each row contains six evenly spaced tiles. Joints between tiles in the same row are at an angle with respect to the radial running direction. This angle maintains a minimum 20 degrees with respect to the radial direction. This heat shield will be designed and constructed to satisfy the demanding flight environments of a Saturn probe of this size. It will utilize flight like materials, design practices, and manufacturing rigor whenever appropriate.



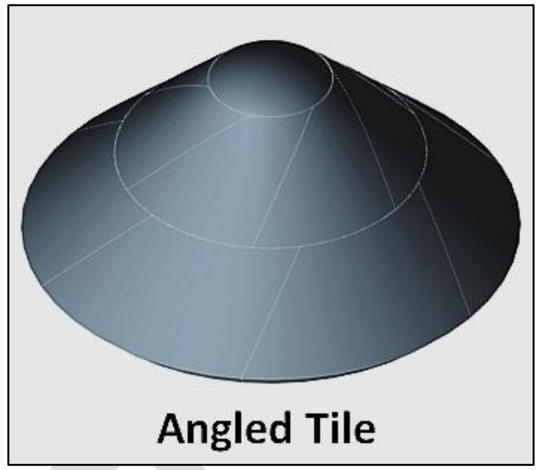


Figure 1: ETU Carrier Structure and TPS (Left) and ETU Tile Geometry (Right)

NASA evaluation of ETU Production will be based on the following criteria:

1. Integration tolerances achieved
2. Manufacturing workmanship requirements achieved
3. Quantity and size of defects
4. Minimization of thickness variation in the bondline thickness
5. Minimum detectable size of various defect types discovered during the inspection via NDE
6. Cost and schedule
7. Level of detail in documentation of ETU build

Prior to construction of the ETU, a series of component level integration tasks and the assembly of a Manufacturing Demonstration Unit (MDU) will be performed. The goal of these tasks is to demonstrate feasibility and develop processes necessary to support the ETU build. Demonstration of processes will be performed on an MDU prior to integrating the ETU. The MDU will comprise a significant, but not complete set of the tiles required to build the ETU for the purposes of verifying/testing all proposed processes.

1.1. Manufacturing and Integration Challenges

Due to manufacturing limitations in the weaving of the preform, the heat shield for the ETU (and future flight applications) will be constructed as an assembly of tiles. Following the weaving of the preform, each tile is rough cut from the dry woven fabric to the proper dimensions, molded into the required curvature (down to a radius of curvature as tight as 7" for a spherical section), infused with a phenolic resin, machined to a final size and shape. NASA is working the aforementioned processes with other vendors.

The integration process assembles the final machined tiles together onto the entry vehicle substructure. The assembly requires that the tiles be both bonded to the carrier structure and joined together to fill any gaps between the tiles and transfer mechanical loads. The current baseline for joining the tiles together is to use a carbon fiber weave infused with silicon. The woven gap filler undergoes a partial cure (using an approach known as B-stage processing), is pressed to the desired thickness, and trimmed to the desired length and depth. The infused woven material is then placed in between the two adjoining TPS tiles and held in place with a fixture during the curing step (see Figure 2). Following the cure cycle, the scrim piece is machined to be flush with the TPS surface.

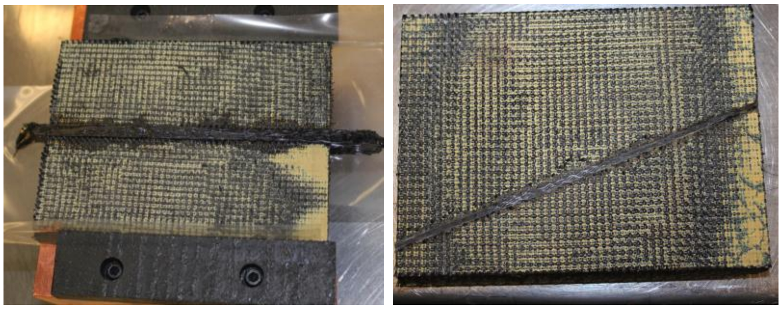


Figure 2: Scrim cloth adhesive joints

The assembly represents a complex integration challenge because of the many operations required and the tolerance requirements that will be levied upon those operations. Management of the tolerance stack up during this procedure is critical to the success of the full thermal protection system. The risk of seam failure due to local flow penetration and the potential for differential recession between the acreage and the seam increase significantly with increasing seam width; therefore it is critical that tight tolerance control be maintained throughout the integration process. Experience and expertise in the assembly and integration of large bonded tile assemblies will increase likelihood that the development of the ETU is a success.

The woven TPS material will range in thickness from 1-3 inches depending on the mission. The material will be infused prior to integration with the carrier structure. The infused material properties for the two different layers of the woven and infused material are listed in the ITAR Appendix, and is available upon request. The individual tiles of the heat shield could be as large as 24” x 24” across and can weigh on the order of 40 lbs.

NASA’s manufacturing and assembly processes for this technology development program require many sequential processes: weaving, molding, resin infusion, machining, integration with the carrier structure, final machining, and NDE. NASA currently has contracts established for weaving the preforms and for molding and resin infusion of the preforms. It is desirable from cost, schedule, and management perspectives that the integrating organization limit the amount of subcontracting to other organizations to accomplish the integration task during this technology development phase. We anticipate the integration and assembly techniques implemented for the ETU be scalable up to a 3.5-meter scale vehicle (during NASA’s mission infusion phase) without significant changes, because future mission implementations of the HEEET technology may extend to vehicle sizes beyond the 1-meter scale of the ETU. The vendor should ensure the methodology in which the ETU is assembled is scalable to up to a 3.5-meter vehicle. HEEET is identified as a GFE and incentivized for the upcoming Discovery 2014 Announcement of Opportunity and developing an integration technique that is scalable up to the 3.5-meter scale is critical to mission infusion.

1.1. Proposed Assembly Procedure

Current installation procedures with an RTV bond process are to perform a dry-fit operation of the entire vehicle. Each tile will be removed individually. Upon removal each panel location is marked both on the tile and the carrier structure. Once dry fit-up and marking is complete installation of the tiles then begins. The nosecap is installed and bonded first followed by the inner row of tiles and then outer row of tiles. The first tile in each row is installed with two straps in the same bond operation. Each successive tile operation in a row includes the tile and the adjacent strap. This is done such that every tile has straps underneath it during the bond operation. The combined strap+tile operation is continued until the keystone piece in each row at which point it will only include the tile as the straps are already in place. Once the inner ring is complete, the outer ring is then assembled in the same manner. During the entire assembly process circumferential seams are maintained with spacers. Once all tiles are assembled on the vehicle, spacers are removed and RTV is injected into the circumferential seams.

Vendors should note that if an elevated temperature bond is performed all fit-up and bonds will need to be performed in a single step. Vendors should also note that the aforementioned process is only a recommendation and not finalized. This integration processis open to modifications based upon vendor feedback. As vendors are responding to this RFI they should keep both options in mind.

1.1. Potential Seam Designs

The current trade space for the seam design remains open. The final seam design must be feasible from an integration standpoint, while meeting the design reference mission structural and aerothermal requirements. The HEEET team is currently performing structural and aerothermal tests on various designs to inform the seam down-select decision. Three primary candidates are currently being carried. These are a butt joint, a 45° scarf joint, and an embedded strap. The three primary seam options are detailed in the Appendix, which is available upon request. The final bonding adhesive choice has yet to be down-selected and would likely be RTV or an elevated temperature cure adhesive. Figure 3 shows the joint configuration. Circumferential seams, or seams that run between rows of tile and the nosecap will be butt joints or joints that are normal to the surface. Seams between tiles in the same row will be one of the three seam concepts detailed in the Appendix. The baseline seam concept is the embedded strap, pending forward testing and assembly verification. Figure 3 also presents the embedded strap concept. Bondline thickness between TPS and carrier structure, and the bottom vertical leg of the seam next to the carrier structure is currently targeted at 0.02" thick. The horizontal adhesive section between recession layers is targeted at 0.01" thick, and the top vertical leg of the seam where the black woven material is shown is 0.07" thick. The woven gap filler documented in Section 1.2 is only on the top vertical leg of the seam. For the butt and scarf joint between tiles in the same row, the woven gap filler material will extend from the surface to the carrier structure.

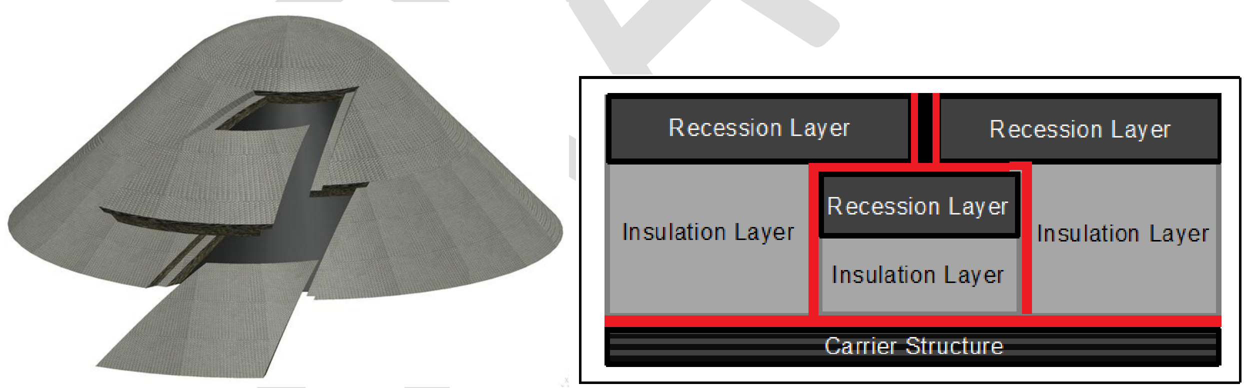


Figure 3: Embedded strap keystone panel installation.

1.2. Introduction: Questions to Vendors

1. As a proposing vendor, which of the following options do you see as the most efficient approach to structuring the management of the ETU build such that the required cost and schedule targets can be met?
    a. NASA manages all processing steps prior to tile integration and delivers the necessary products to the vendor to complete the integration and NDE steps described in the SOW below (current project assumption, as reflected in remainder of this RFI).
    b. Vendor manages a subset of the processing steps and coordinates through NASA to manage the others (e.g. machining)

   c. Vendor manages and oversees all processing steps (weaving through final inspection)
   d. Other
2. Please describe any previous experience and expertise in woven materials, integration of thermal protection materials, and other relevant aerospace systems.
3. Please describe any previous assembly experience with RTV, Epoxy, or adhesives which require an elevated temperature cure.
4. Selected Vendor will be supporting the development of the integration steps and processes for the ETU build. Furthermore, NASA may request that the vendor support future mission infusion time-line, depending on the selection of missions in the upcoming Discovery or New Frontier opportunities. Does the vendor foresee any challenge or limitation that NASA should be aware of in the future?

2. REPRESENTATIVE SCOPE AND OBJECTIVES

The following task breakdown is representative of the anticipated Statement of Work (SOW) for a future Request for Proposal (RFP) solicitation for the manufacturing and integration of the HEEET ETU. Information received from industry in response to the RFI may result in revisions to the final SOW. It is currently anticipated that a future procurement will result in a single award contract requiring the 5 tasks outlined below. Following this initial feedback, NASA may conduct one-on-one meetings and/or site visits with potential parties. These meetings will allow for exchange of information and will provide an opportunity for potential offerors to provide feedback on the Government's requirements and its acquisition approach. However responses to this RFI may influence the final RFP requirement.

2.1. Task 1: 4 Point Bend Specimens

Task 1 will be a component level integration of small specimens of the HEEET material onto a composite substructure. These components will be used by NASA in a 4-point bend test to assess the structural performance of the as constructed seam in bending. These tasks will be conducted in the manner described in the steps below, with the only difference being the type of joint being constructed. NASA will provide the substructure and machined TPS tiles required to assemble the 4-point bend specimens. The joint design may be any or all of the three options provided in. For more details refer to the Appendix.

For each Task, NASA will deliver the carrier structure substrate to be used for bonding and the HEEET material in a state of integration readiness that is representative of the material state which is expected to be delivered for ETU integration (if machining is not performed by the integration vendor): resin infused, and machined to the desired shape. It will be up to the vendor to confirm the as delivered state meets the design specification upon arrival from the machining vendor. If any modifications are required to achieve the desired tolerances they shall be documented and reported out to NASA. If the vendor chooses to machine, then NASA will deliver resin infused material. NASA will provide guidance on the best practices for the implementation of the seams and the bonding of the material to the substrate. It will be up to the vendor to employ these techniques and/or their own best practices to achieve the required final product. Following integration, the vendor will conduct NASA approved NDE to characterize the defects present in the bondline, seams, and acreage material.

Task 1 Steps:

1. Initially, NASA provides the following:
   a. 6 composite sandwich substructures of 24x4x0.25" thickness.
   b. NASA provides 12 machined, resin infused blocks of 8" x 4" x 2.1" within 0.01" tolerance on all sides.
   c. NASA provides detailed assembly drawing and process documents

2. Vendor tiles with the seam centered on the center of the substrate as per provided assembly drawings. Anticipated seam width is 0.07” (TBR) with a tolerance of 0.02” (TBR).
3. Vendor performs final OML surface machining of the part for seam cleanup.
4. Vendor performs NDE of final part to characterize any defects present.
5. Vendor provides final assembled parts for approval and a report detailing NDE results, tolerance control, key challenges, feedback to NASA, and detailed procedure for scale-up to a seam thermal strain panel (described below) to NASA.
6. NASA evaluates workmanship of vendor integration and verifies tolerances and NDE results.

Prior to proceeding with the construction of the MDU in Task 4, NASA will conduct evaluation of Task 1 based on some or all of the following criteria:

1. Integration tolerances achieved relative to design specifications.
2. NASA performs testing to evaluate joint strength consistency in tension and bending with a goal of meeting the minimum threshold strength value required by NASA (TBD). Iterative coupon testing may be required pending variance and strength value determined from testing.
3. Proposed scale up procedure for the seam thermal strain panel.
4. Thickness variation in the seam widths, bondline thickness, and outer mold line of the exposed top surface.
5. Minimum detectable size of various defect types discovered during the inspection via NDE.

2.1.1. Task 1: Questions to Vendors

1. Task 1 will be the first time for a vendor to work with the HEEET material. What do you anticipate will be required to familiarize yourselves with the material and the seam concepts prior to performing the integration of the 4-point bend test articles?
2. Please describe any existing NDE capabilities that you anticipate will be applicable to assessment of the integration quality of the test specimens.
3. Would it be preferred to have NASA provide tiles that are already machined to the specified tolerances or oversized, resin infused tiles to be machined by the vendor?
4. What is the cost and schedule impact associated with each seam design assuming an elevated temperature bond operation and a room temperature bond operation.
   a. Embedded strap
   b. Scarf Joint
   c. Butt Joint

2.2. Task 2: Seam Thermal Strain Panel

This task will establish feasibility of joining tiles of the HEEET material together in a grid-like pattern on a representative substrate and at a relevant scale while maintaining specified tolerances. The specimen constructed in this task will be used by NASA to conduct thermal strain testing.

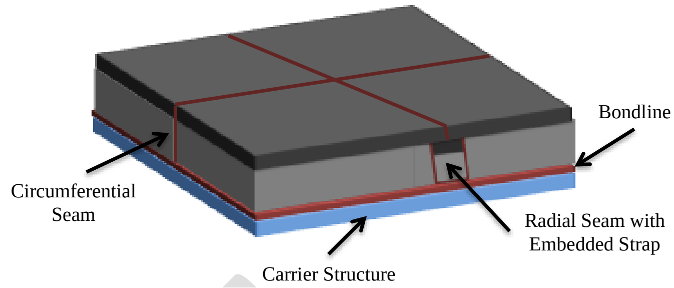


Figure 4: Schematic of panel assembly for Task 1

The tile layout will consist of four tiles, each 12” x 12” x 2.1”, arranged in a 2x2 grid. Along angled boundary between the two columns of tiles, there will be a seam representative of the angled radial seam baselined for the ETU. Along the horizontal interface within the tile grid will be a seam representative of the circumferential seam design baselined for the ETU (see Figure 4). NASA will deliver the carrier structure substrate and the HEEET material resin infused and machined to the desired shape. It will be up to the vendor to confirm the as delivered state meets the design specification upon arrival and perform any required modifications to achieve the desired tolerances. These modifications shall be documented and reported out to NASA. If the vendor chooses to machine, then NASA will deliver resin infused material. NASA will provide guidance on the best practices for the implementation of the seams and the bonding of the material to the substrate. It will be up to the vendor to employ these techniques along with their own best practices to achieve the required final product. Following integration, the vendor will conduct NDE to characterize the defects present in the bondline, seams, and acreage material. The vendor shall provide some insight into how they anticipate their integration and NDE processes would be scaled up for use on the ETU and even larger vehicles. Vendor shall provide suggested methods to address repair of defects in the seam and the carrier structure bondline.

Task 2 Steps:

1. NASA provides the following:
    a. 1 composite sandwich substructure of 24” x 24” x 1”.
    b. NASA provides 4 resin infused tiles within 0.01” tolerance on all sides.
    c. NASA provides detailed assembly drawing and process documents.
2. Vendor assembles Thermal Strain Panel assembly of tiles per provided design specification. Anticipated seam width is 0.07” with a tolerance of 0.02” (TBD).
3. Vendor coordinates final surface machining of the part for seam cleanup.
4. Vendor performs NDE of final part to characterize any defects present.
5. Vendor provides assembled parts and a report detailing NDE results, tolerance control, key challenges, feedback to NASA, and a detailed procedure for scale-up to the MDU to NASA.
6. NASA evaluates workmanship of vendor integration and verifies tolerances and NDE results.

Prior to proceeding with the construction of the MDU in Task 4, NASA will conduct evaluation of Task 2 based on some or all of the following criteria:

1. Integration tolerances achieved relative to design specifications.
2. NASA will perform testing to demonstrate minimum joint strength is attained when the panel is thermal cycled.
3. Ease of scale-up of integration and NDE processes to 1 meter ETU.
4. Minimization of damage to the material and substrate (during handling).
5. Thickness variation in the seam widths, bondline thickness, and outer mold line of the exposed top surface.
6. Minimum detectable size of various defect types discovered during the inspection via NDE.

7. Ease of implementation of proposed repair techniques.
8. What is the cost and schedule impact associated with each seam design assuming an elevated temperature bond operation and a room temperature bond operation.
    a. Embedded strap
    b. Scarf Joint
    c. Butt Joint

2.2.1. Task 2: Questions to Vendors

1. What, from the following options, do you anticipate will be required to scale up the lessons learned in Task 1 to assemble the **Thermal Strain Panel** in Task 2?
    a. Spare material for seam-integration practice?
    b. Tooling foam mock-ups for seam integration practice?
    c. Other?
2. Would it be preferred to have NASA provide tiles that are already machined to the specified tolerances or oversized, resin infused tiles to be machined by the vendor?
3. If an elevated temperature bond operation is required, what is the current maximum size that can be accommodated?
4. What issues do you anticipate with an elevated temperature bond operation as opposed to a room temperature bond operation?

2.3. Task 3: Development of integration processes for scale-up to ETU

This task will establish the forward plans for developing the MDU and ETU. The MDU will be constructed with the same processes planned for the ETU, but will likely only use a subset of the full heat shield tiles. NASA will provide the vendor with MDU/ETU geometry, ETU requirements, and design guidance. The vendor will apply lessons learned in Tasks 1-2 to develop detailed processes and preliminary designs for successful integration of the HEEET ETU. The processes developed in Task 3 shall be applicable to both the MDU and the ETU and the plans should elaborate on the plans to incorporate the lessons learned from the MDU into the integration ETU. Vendor shall provide description of all facilities, subcontractors, and additional resources that are intended for use to complete the ETU integration. The documentation for each aspect of the integration shall include detailed cost and schedule estimates.

Task 3 Steps:

1. NASA delivers MDU/ETU design documentation and requirements.
2. Vendor provides process documents for each of the following:
    a. Handling procedures
    b. TPS integration procedures
    c. Basic repair & contingency procedures
    d. Bond curing facilities and procedures
    e. Plans and protocol for interfacing with outside entities to support ETU build
    f. NDE processes and defect repair plan
3. Vendor provides preliminary designs for each of the following:
    a. Ground support equipment
    b. Integration tooling and fixtures
    c. NDE tooling and fixtures
4. Vendor provides cost and schedule estimate for each item listed in Steps 2 and 3 above
5. NASA evaluates vendor proposal for ETU integration

NASA evaluation of **ETU process scale-up plans** will be based on some or all of the following criteria:

1. Anticipated integration tolerances achieved
2. Previous utilization of proposed processes, facilities, and personnel
3. Cost and schedule
4. Ease of scale up to vehicles up to 3.5 meters in diameter
5. Variety and defect resolution of proposed NDE processes and equipment
6. Proposed repair techniques

2.3.1. Task 3: Questions to Vendors

1. For the various seam options, what is envisioned as the preferred order of operations for the integration of the heat shield system onto the carrier structure with regard to:
    a. Tiles and seams?
    b. Nosecap, inner row, and outer rows of tiles?
2. What aspects of the integration process do you expect to differ between the MDU (partial set of ties) and the ETU (complete set of tiles) and why?
3. Which aspects of the MDU/ETU design and/or requirements do you expect to drive cost, schedule, and integration performance of the ETU?
4. Please describe the way in which you would plan to track risks in the areas of schedule, cost, and performance. How would these risks be communicated out to NASA?
5. What is the cost and schedule impact associated with each seam design.
    a. Embedded Strap
    b. Scarf Joint
    c. Butt Joint
6. What, if any, modifications to the assembly process operations documented in the introduction would the vendor propose?

2.4. Task 4: Production of Manufacturing Demonstration Unit

Task 4 will involve the development and delivery of a full scale Manufacturing Demonstration Unit (MDU) using processes, tooling and fixtures, facilities, outside organizations in line with those specified in Task 3. This task will act as final step to fully understand the integration challenges associated with the HEEET ETU so that lessons learned can be fed forward and incorporated into the ETU design, manufacturing, and integration. NASA will provide procedural guidance based on feedback from tasks 1, 2 and3. The MDU build will consist of 1 nosecap, 5 inner straps, 5 outer straps, and 4 tiles at the inner and outer ring to demonstrate capability and implementation of NDE following integration.

Task 4 Steps:

1. NASA completes evaluation of Tasks 1-3 and provides authority to proceed with Task 4
2. Vendor finalizes MDU manufacturing and assembly plan: proposed processes, facilities, ground support equipment, NDE techniques, personnel, and subcontractors to be used.
3. NASA reviews and approves the manufacturing plan proposed by vendor.
4. NASA provides the following:
    a. Composite substructure: 45 degree spherecone, 1 meter diameter
    b. NASA provides resin infused TPS material manufactured within 0.02” tolerance on all sides.
5. Vendor completes MDU build using agreed upon procedures planned for the ETU. Anticipated seam width is 0.07” with a tolerance of 0.02” (TBD).
6. Vendor performs NDE of final assembly to characterize any defects present.
7. Vendor demonstrates repair procedures as needed or as required (TBD)
8. Vendor delivers MDU and associated documentation
    i) Requirements verification

   ii) Processes checklists
   iii) Acceptance criteria documentation, i.e. final part acceptance measurements.
9. Vendor provides cost and schedule actuals for MDU build.
10. Vendor provides lessons learned and modifications to forward plan for ETU build that includes changes to schedule and cost.

NASA evaluation of **MDU Production** will be based on the following criteria:

1. Integration tolerances achieved
2. Quantity and size of defects.
3. A report on damage to the material and substrate (during handling and assembly) and how to prevent it in the future.
4. Lessons learned for minimization of thickness variation in the seam widths, bondline thickness, and outer mold line of the exposed top surface and an estimate of variation that is achievable.
5. Minimum detectable size of various defect types discovered during the inspection via NDE
6. Cost and schedule
7. Level of detail in documentation of MDU build and proposed modifications to integration plans for ETU build

2.4.1. Task 4: Questions to Vendors

1. The intent of the MDU is to provide an opportunity to exercise the planned processes for the execution of the ETU integration. Lessons learned from the MDU will be fed forward into ETU production. To ensure proper implementation on the ETU, which of the following would you recommend the scope of the MDU be?
   a. Full heat shield integration: NASA will supply a full set of TPS tiles to assemble a full heat shield and the vendor will conduct a full end-to-end integration using the ETU processes.
   b. Partial heat shield integration: NASA will supply a subset of TPS tiles (e.g. 1 nosecap, 4 inner row tiles, and 4 outer row tiles) such that the vendor can exercise the seam integration, a keystone tile integration, and the integration of the nosecap. The integration of this partial set of tiles including key operations representative of the ETU will provide a sufficient learning experience to successfully assemble the ETU
   c. Other
2. What do you anticipate the largest unknown going into the MDU build will be? How much time should be allotted to incorporate lessons learned from the MDU into the ETU integration design?
3. How sensitive is complexity, schedule, and cost of assembly to specified seam width and allowable tolerance on seam width?
4. From an integration perspective do you have a recommendation on what a feasible minimum attainable seam width is?
5. Would it be preferred to have NASA provide tiles that are already machined to the specified tolerances or oversized, resin infused tiles to be machined by the vendor?
6. What is the cost and schedule impact associated with the embedded strap seam design concept.
7. What is the cost of the documentation below?
   a. Requirements verification
   b. Process Checklists
   c. Acceptance criteria documentation, i.e. final part acceptance measurements.
8. What, if any, modifications to the assembly process operations documented in the introduction would the vendor propose?
9. If an elevated temperature bond operation is required, what is the current maximum size that can be accommodated?
10. What issues do you anticipate with an elevated temperature bond operation as opposed to a room temperature bond operation?

2.5. Task 5: Integration and Delivery of ETU

Task 5 will involve the development and delivery of a full scale (1 meter diameter) Engineering Test Unit (ETU) using processes, tooling and fixtures, and facilities with those specified in Task 3 and demonstrated and modified in Task 4. This task will deliver the key piece of hardware for the HEEET project. The ETU will go on to undergo a suite of environmental load tests to assess is structural performance and verify the design and manufacturing techniques for future use on flight missions. NASA will provide procedural guidance, a full-scale carrier structure and a full set of TPS material to produce a fully integrated system, including spares.

Task 5 Steps:

1. Vendor finalizes ETU manufacturing and assembly plan: proposed processes, facilities, ground support equipment, NDE techniques, personnel, and subcontractors to be used.
2. NASA reviews and approves the integration plan proposed by vendor.
3. NASA provides the following:
    a. Composite substructure: 45 degree sphere-cone, 1 meter diameter.
    b. NASA provides resin infused TPS material sufficient for full ETU build plus spares, each manufactured within 0.02” tolerance on all sides.
4. Vendor verifies that each part is within an acceptable tolerance.
    a. Vendor accepts or rejects each part. Upon part rejection, vendor coordinates with NASA to either modify the part or request a replacement part.
5. NASA delivers assembly drawings, carrier structure, and TPS materials to vendor.
6. Vendor completes ETU build using agreed upon procedures. Anticipated seam width is ~0.07” (TBD) with a tolerance of ~0.02” (TBD).
7. Vendor performs NDE of final assembly to characterize any defects present.
8. Vendor delivers ETU and associated documentation (requirements verification, processes checklists, QA documents, etc.) to NASA.
9. Vendor provides cost and schedule actuals for ETU build to NASA.
10. Vendor provides lessons learned and modifications to forward plan for integration of future implementations of the HEEET technology.
11. NASA evaluates ETU integration and verifies that the as delivered hardware meets acceptance criteria for testing.
12. NASA conducts environmental testing on ETU.
13. Vendor conducts post-test NDE of ETU.

NASA evaluation of **ETU Production** will be based on the following criteria:

8. Integration tolerances achieved
9. Quantity and size of defects
10. Minimization of thickness variation in the bondline thickness
11. Minimum detectable size of various defect types discovered during the inspection via NDE
12. Cost and schedule
13. Level of detail in documentation of ETU build

3. Deliverables

The timeframe for completion of all activities (Tasks 1-5) are structured such that NASA can evaluate performance intermittently and work with the vendor to improve processes for the following tasks. The planning activity in Task 3 will be conducted in parallel to development of Tasks 1-2 such that the processes being developed for the MDU/ETU integration can be incorporated into and improved upon from Tasks 1-2. Vendors are strongly encouraged to provide ROM estimates for schedule and costing of each task.

3.1. Content for RFI Respondees:

RFI responses should address items outlined below and Task questions specifically spelled out above:

1. Provide an indication of the level of interest and ability to perform tasks (1-5), either all or a subset of the tasks. If current existing facilities are insufficient for performing one or more of the tasks, please indicate the level of investment required to allow for successful completion of the task(s).
2. Provide a cost and schedule assessment for each task.
3. Provide an assessment of the feasibility of the different joint design options and the relative scale of the concepts in terms of cost, schedule, complexity and risk for the different concepts. (Likely development cost of concept A is “x” times that of concept B, etc.).
4. Given the respondee’s background and level of expertise relative to the type of work outlined in Tasks 1-5, what is the respondee’s comfort level with a firm fixed price type of contract?
5. The processes and procedures developed under this contract are intended to be the property of NASA and to be able to be shared with other parties, particularly if the awardee is no longer able or willing to provide integration services in support of future NASA missions. Please comment on any concerns with this approach. The intent of the HEEET project is to develop a capability that is available for any proposing organization to utilize. Therefore it is in NASA’s best interest that any awardee for integration under this contract be willing to provide integration services to all proposing organizations.
6. Current capability in large scale integration of aerospace structures:
    a. Floor space, vacuum equipment, and ovens applicable to the 1-m scale ETU
    b. Personnel experienced in designing necessary tooling needed for the MDU/ETU
    c. Personnel or subcontractor experienced in appropriate Non Destructive Evaluation (NDE)
    d. Associated product assurance certifications and processing equipment necessary to do so
7. Ability to lift and manipulate large (up to 3.5m diameter), massive components and systems
8. Ability to achieve assembly tolerances of +-0.02” in the assembly of large systems. List available supporting infrastructure that has been used in the past for such applications (laser projection system, etc).
9. Ability to perform large scale bonding operations
10. Ability to do an elevated temperature cure of the fully assembled system at temperatures up to 200ºC
11. Ability to perform large vacuum bag operations for the bonding process and potentially for molding of the fabric prior to resin infusion
12. Provide information on previous experience in working with adhesive bonding agents for large scale bond operations
13. Provide information on previous efforts to assemble large scale systems with many interfacing surfaces for both:
    a. Room temperature cure adhesives
    b. Elevated temperature cure adhesives
14. Provide information on evaluation of bond quality between two mating surfaces (NDE or other)
15. Provide information on identification and evaluation of in-plane and through the thickness cracks in relevant related systems (NDE or other)
16. Provide information regarding the potential extension of the necessary processes and infrastructure from the 1-meter scale to the 3.5-meter scale. What aspect of this scale-up presents the greatest challenges either technically or financially?
17. Provide some indication of costs and schedules for modifications of current facilities, if required, to accommodate each of the tasks.
18. Provide feedback on the questions proposed at the end of each task.